DOCUMENT RESUME

ED 225 591 IR 050 090

AUTHOR	Oettinger, Anthony G.
TITLE	Harnessing the Age of Information.
INSTITUTION	Business-Higher Education Forum, Washington, D.C.
PUB DATE	18 Jul 81
NOTE	22p.; Paper presented to the Business-Higher Education Forum of the American Council on Education (Washington, DC, July 18, 1981).
PUB TYPE	Viewpoints (120) -- Speeches/Conference Papers (150)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	Arithmetic; *Educational Change; Futures (of Society); Information Networks; Information Services; *Information Sources; *Literacy; Newspapers; Social Change; *Technological Advancement
IDENTIFIERS	Geopolitical Change; Information Industry

ABSTRACT

Drawing in part on experiences from Harvard University's Program in Information Resources Policy, this paper looks at societal implications of changes in information resources and suggests concomitant changes in education. Commercial and geopolitical effects of the expansion in the range and versatility of information and communications products and services are discussed, and a modern definition of literacy is proposed which includes familiarity with computers and other information resources. The wisdom of concentration on drills in arithmetic and writing skills, rather than use of calculators and keyboards, is questioned. Mention is also made of the need for a new elementary school curriculum, the effect of new information technologies on the newspaper industry, and the increasing rate of technological change. Excerpts from a subsequent question-and-answer session and biographical details of the author conclude the pamphlet. (ESR)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

HARNESSING THE AGE OF INFORMATION

ED225591

by Anthony G. Oettinger

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

- This document has been reproduced as received from the person or organization originating it.
  Minor changes have been made to improve reproduction quality.
- Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Alan H. Magazine

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

IR050090

An Address by:
Anthony G. Oettinger
Chairman, Program on Information Resources Policy, Harvard University

Before the
Business-Higher Education Forum

Business-Higher
Education Forum
One Dupont Circle, Suite 800
Washington, D.C. 20036
(202) 833-4716

in affiliation with the American Council on Education

The age of information has enormous significance not only for business and higher education but for almost everything else as well. Information, like energy and material, is a basic resource. The cost of labor of every kind and the capital cost of most things is going up. But information resources of certain kinds represent an area where —although they share in rising costs of labor— capital costs are rising less sharply than elsewhere in the economy.

What are information resources? The best way I can characterize them briefly is by the terms *conduit* and *content*. "Conduit" may be thought of as similar to a blank piece of paper which can convey information only after someone writes something on it. As a "content" product, a book is the quintessential example. When people burn books, we regard them as perverts. The main purpose of a book is to convey content, and the content is fixed. Information businesses sell conduits or content —or mixtures of the two— either as products or as services.

What has happened over roughly the last fifty years is that the range and versatility of information products and services have broadened tremendously. Since the 1930s the computer and other electronic devices have been at the heart of the phenomenon of decreasing capital costs. But along with sharp changes in

labor and capital costs have come some rather nasty movements and conflicts in functional regulation. The regulatory bodies now in place reflect an older, calmer time when people knew, for example, what the U. S. mail was or could tell financial services from telecommunication services.

Information, like energy and material, is a basic resource

Traditional regulatory authority was clear-cut: telephonic transmission and broadcast matters fell to the Federal Communications Commission; mail belonged to the Postal Rate Commission; financial services were regulated by the Board of Governors of the Federal Reserve System, the Comptroller of the Currency, the Home Loan Bank Board, and dozens of other agencies at the federal and state levels. There were a variety of regulators such as the Federal Trade Commission for advertising services.

Over the last two decades, however, these agencies have come into conflict as the turf boundaries of their "regulatees" has blurred and their own missions have become uncertain. One sees such spectacles as the Federal Communications Commission and the Postal Rate Commission suing each other in federal court concerning which has jurisdiction over what in those peculiar areas where electronic movement of information and physical movement of information run into each other.

It used to be that a newspaper, delivered on the doorstep every morning, coexisted with a corporate entity. The newspaper product and the newspaper corporation were pretty much congruent. Today, however, some six or seven of the largest newspaper corporations are engaged in diversified information businesses well beyond their basic newspaper publishing. This expansion

brings them into conflict with other business entities such as American Telephone and Telegraph (AT&T), whose potential deregulated shape may place them squarely in the marketplace of the new information services.

The fact of overlap in business interests has struck some consternation in the hearts of members of the American Newspaper Publishers Association. I must say they had the wisdom, when they realized that AT&T might get into the classified advertising business, to call on our program[1] for help in understanding their predicament. We were able to help them understand the issues, as we have helped AT&T and others, but we could not help in resolving the issues. The publishers, AT&T, United Telecommunications, and many others with stakes in the information business are still in Washington wrestling with the FCC, the Congress, the executive branch, and the courts over turf.

As is often the case with changes in fundamental resources, changes in information resources are having some profound geo-political effects, for example, on national security, transborder data flow, and privacy. They are, in a metaphorical sense, contributing to changing the shape of our nation. One change is distance, not in terms of miles, but — put simply — in prices of long distance phone calls. The years since 1957 have seen a progressive increase of competition among the telephone industry as traditionally conceived and other communications industries, less traditionally conceived.

Like the consequences introduced by canals, railroads, jet aircraft, and so on, the consequences of the information explosion on the shape of the nation, indeed of the world —

---

1. The Program on Information Resources Policy, a joint venture of Harvard University and the Center for Information Policy Research, investigates changes and developments in the field of information and communications technology and policy.

in response to a combination of technical, political, and social changes even of this magnitude — may not be immediately evident. Meanwhile, the consequences of evolution in the information and communications industries are commanding continual attention from numerous congressional committees and federal and state regulatory commissions.

Like the consequences introduced by canals, railroads, jet aircraft, and so on, the consequences of the information explosion on the shape of the nation, indeed of the world – in response to a combination of technical, political, and social changes even of this magnitude – may not be immediately evident.

We already know about some massive geopolitical changes brought on by the changes in the last forty years in information technologies. One manifestation is the change in proportion of occupations in the United States. Agricultural occupations peaked around 1880 and have been declining ever since. Industrial occupations peaked during the two World Wars. Service occupations have held their own. The slack in the work force left by agricultural and industrial workers has been taken up by information occupations — teachers, accountants, computer programmers, newspaper men, managers, for that matter — people who do not turn out a sheaf of wheat or a nut or bolt, but sell advice or write books or give orders or otherwise manipulate information.

This phenomenon is by no means limited to the United States. The Organization for Economic Cooperation and Development

(OECD) recently studied the advanced industrialized nations. While the United States leads with, as of about 1970, 40 percent of the labor force in information occupations, Canada is not far behind, then the United Kingdom, Sweden, France, Japan, and so on. This trend is common to all the industrialized nations and is not some kind of fluke.

Again, the consequences of the shift in occupations are enormous in most any dimension of life that one might mention. Everybody continues to be fascinated by newspapers and the television media. I maintain that to do so is resolutely to look backwards. Not that these media are unimportant. The newspapers and broadcast television (contrary to nonsense about electronic newspapers and cable TV taking over) will be with us for a long time. Paper has certain irreducible advantages for which no amount of electronics can substitute. But it's no longer the sole rooster in the barnyard. The Iranian revolution provides an excellent example.

Paper has certain irreducible advantages for which no amount of electronics can substitute. But it's no longer the sole rooster in the barnyard. The Iranian revolution provides an excellent example.

In the olden days we knew a revolution had taken place when an insurrectionist took over the local radio station and announced, "We're in charge." In Iran, the revolutionaries didn't bother taking over the radio station. They didn't bother taking over the television station. The shah stayed in control of all the traditional media. But that didn't matter any more. Why? Khomeini and his people sat in Paris and used

direct distance dialing to telephone their friends throughout Iran, using facilities installed in large measure by means of U. S. technology.

What didn't travel by telephone was sent by cassettes — cheap little cassettes of a type anybody can buy at Radio Shack — that went by mail or messenger. And the cassettes were duplicated and circulated. What didn't go by cassette was transcribed and then Xeroxed. And what didn't get Xeroxed got read by the imams in the mosques. One of my friends, an Iranian who was with National Iranian Radio and Television, being a Harvard Ph.D. in history, had had the brains to buy a house in New England and move out just before things got bloody. Later, he said to me, "Our movement was for democracy against autocracy by means of Xerocracy."

"Our movement was for democracy against autocracy by means of Xerocracy."

(National Iranian Radio and Television Official)

And the moral of that is: Our intelligence agencies, our media, and so on have still, by and large, not awakened to the fact that there are now "retail media" like Xerox machines, like audio cassettes, like video cassettes. Remember the big hassle when the Saudis tried to get a ban on the showing of "Death of a Princess" in the United States? This documentary has an enormous circulation in Saudi Arabia — an underground circulation, through cassettes. It is viewed there over and over again, and the Saudis can do very little about it; it's hard to control traffic in cassettes. So retail information technologies — from imams in mosques through cassettes through high-technology direct distance telephone dialing — have altered the shape of political insurgency.

Examples could be multiplied, but let me turn to an example that is particularly relevant for this business-higher education group. There has been a shift in our conception of literacy, which I think follows from combined technological and social change. In Western civilization this point can be made by examining the transition in England from the use of memory as the principal form of administrative, judicial, and business record to the use of written records. At the time of the Norman Conquest in 1066, when somebody would say "Bring on the record," ten knights would march up and be sworn in and depose. By 1307, one knight or his delegate might march up and bring some written material. Thus, between 1066 and 1307 the definition of "record" changed drastically.

The definition of literacy also changed drastically from something that was the sole province of clerks in monasteries and perhaps of the king and his court. Domesday Book was indeed a written record, but it was only for show; it did not serve as a working inventory of King William's resources. By 1307 there were working written inventories of the king's resources, and even serfs were making contracts with one another in writing, not orally. A profound transformation.

Not much happened really for another few hundred years. People keep pointing to Gutenberg's invention of movable type as a milestone. It did have some effects, but less profound politically than the invention of the rotary press in the nineteenth century. That invention and, in general, the industrial revolution — the development of the railroads — again transformed our notions of literacy. The impetus for literacy in the nineteenth century came when education — the three Rs — was regarded as, not a matter only for the elite, but as a way of increasing the productivity of the masses. This was done, as observers noted, at the risk of considerable social unrest, often attributed to the rise in literacy. The parallel between the hand

wringing over television today and the hand wringing over the penny dreadfuls, the mass press, and even novels in the nineteenth century is fascinating but often overlooked. I commend for attention that literacy was conceived, at least by some folks in those days, as intimately related to productivity.

What I am leading up to is the question, What, in modern terms, is a reasonable definition of literacy? Let me cite a recent letter from a friend who, at one time, was a member of Harvard's Board of Overseers. He took, he says, "every opportunity to insist that it was now as much of a sin to graduate a person from college without at least elementary knowledge of computers as it was to send him out in the world without an adequate knowledge of English." That's a bit too narrowly put, but if computers are thought of as a metaphor for all modern information resources, it's on mark.

". . . it was now as much of a sin to graduate a person from college without at least elementary knowledge of computers as it was to send him out in the world without an adequate knowledge of English."

The theme was taken up recently in a *Boston Globe* article (7/6/81), "Schools Don't Change Fast Enough." Among other things, it said: "While the youngsters are talking and thinking in the computer language that may be the universal idiom of the future, the schools are still using outdated Dick and Jane type texts to teach reading and writing." Again, I think many people take "computer language" too literally. But again using "computer" as a metaphor for changing notions of literacy, we have a question of some importance and one where, I think, business and higher education have particular

responsibility for leadership. The question is tripartite: How basic are the three Rs; what is the meaning of literacy for the '80s and '90s; and what, if anything, do we do about it?

Obviously, I am convinced that something needs to be done. Why? Let me give one example. Among the three Rs, literacy in the classical sense has included reading. But what about writing and arithmetic? Arithmetic why? The nineteenth century needed bookkeepers; it needed clerks who could make change. The epitome of these people is Bob Cratchit and others in the world that Dickens depicted. But

"While the young sters are talking and thinking in the computer language that may be the universal idiom of the future, the schools are still using outdated Dick and Jane type texts to teach reading and writing."

when was the last time anyone has seen a clerk or cashier add up a grocery bill in their head or on a piece of paper? Hardly a supermarket, hardly even a ma-and-pa grocery store is left where there isn't some kind of electronic gadgetry used to add up the bill. One of these days all the clerks will be waving a hand over the Uniform Product Code on the side of the piece of produce or canned goods, and there won't even be any need to punch in the numbers.

This advance may be all well and good. But what if the arithmetic skills atrophy? What happens if there is a power failure and adding machines don't work? I point out that if the power goes off, the supermarket is dark, the meat is rotting, and the last thing the supermarket manager or customer will worry about is whether somebody can add up the bill. We have

ever so many sensitive spots in our society that could be put out of commission by a saboteur or a striker. The effect of a power failure is a teeny red herring compared to real threats. What happens, for example, if we have a major nuclear exchange? This again is a matter of importance regarding information resources. The whole question is whether indeed this nation and the Soviet Union have viable nervous systems that can command and control withholding or releasing nuclear forces. The matter is of greatest concern.

One of these days all the clerks will be waving a hand over the Uniform Product Code on the side of the piece of produce or canned goods, and there won't even be any need to punch in the numbers.

And the matter is not one of esoteric computer technology. President Carter was perhaps the first president to practice what he might have to do if the time came to push the button. At the appointed hour the helicopter came over to the White House from Andrews Air Force Base to pick him up and evacuate him. The Secret Service never got the word, so they nearly shot the helicopter down. So there is a lot to think about. The concentration on muscle, on materials and energy, to the exclusion of information resources leads us to some strange things. We have these mammoth nuclear arsenals, lots of muscle, but the nervous system is not fit for an ameoba. Ponder that!

But back to basic reading and writing. Drill and practice. I estimate that $10 billion to $20 billion a year (I could even shave it down to $5 billion or blow it up to $50 billion, it's easy to lie with such figures) is spent in elementary and

secondary schools on arithmetic drilling. Why? Because we've always done it that way. Well, not always. We've done it since the nineteenth century because we needed those skills. Textbooks nowadays cost about $20. A four-function calculator costs $4 or $5. Why are we still drilling children in arithmetic? Now the question becomes whether we might want to use the time released from that drill to teach deeper mathematical analysis (which might be a useful thing to do) or get rid of math teachers. I leave that idea as an exercise. But I urge careful examination — in a period of tight budgets, Proposition 2½, and so on and on — of the question, why are we still teaching arithmetic skills that are replaced by a hand-held calculator?

An increasing portion of the clerical work force is no longer writing with a goose-quill pen or even a ball-point pen in a fine round hand. About seven million of them in the United States are punching keys on about five million video display terminals.

Why are we still teaching writing in a fine round hand, again a Dickensian kind of an image, when it is estimated that today some five million — up from two million, estimated about four years ago — video display terminals are in use by airline reservation clerks, telephone operators, bank clerks, insurance clerks, and the like. An increasing portion of the clerical work force is no longer writing with a goose-quill pen or even a ball-point pen in a fine round hand. About seven million of them in the United States are punching keys on about five million video display terminals. These numbers are not very firm: nobody keeps a good census. We still carefully measure freight car loadings, but there

are no good numbers on how many people are out there punching keys.

The point is that, as a work place skill, writing with a fine round hand is getting less and less useful compared to the ability to deal effectively with a keyboard. I consider myself quite handicapped by my inability to deal effectively with a keyboard. I'm just at the break

Because, whether they are going to be clerks or chief executive officers, I believe that over the next generations the ability to bang away at a keyboard will be a far more valuable skill than the skill of writing in a fine round hand.

point of the generations. My children, thanks to my realization, are damn good at keyboards, and I hope yours are as well. Because, whether they are going to be clerks or chief executive officers, I believe that over the next generations the ability to bang away at a keyboard will be a far more valuable skill than the skill of writing in a fine round hand.

These questions are in part literal questions, but they are also in part metaphorical questions meant to make you think about whether our notions of literacy inherited from the industrial revolution are still appropriate notions for the 1980s and the 1990s.

Anthony G. Oettinger
July 18, 1981

At the conclusion of his presentation, Professor Oettinger entertained questions from Forum members. Following are excerpts from that exchange.

If you were starting from absolute scratch to develop an elementary school curriculum, what would be in it – with emphasis on what you were talking about today?

Oettinger: I shall not try to answer that question here but, rather, suggest some directions to think about. Some things never change. In our fascination with the new, we often ignore that new technologies simply reopen old questions. And the basic questions of teaching people to learn how to think, how to solve problems, and so forth, remain as they always have.

I think that the means have changed and that we need to reinterpret the basic objectives of schools — developing problem-solving ability, ability to understand the world, knowledge of certain substantive materials that are regarded by the community as being more important than other substantive materials — but by different means. That's why I use the metaphor of the hand-held calculator. At five bucks a throw, it is cheaper than an arithmetic textbook, and time can be saved by teaching how to manipulate the calculator as opposed to drilling and practicing how to add columns of figures.

The inveighing against television in an era when most children, for better or worse — I'm not an elitist on that score; I think it's perhaps for the better and, in any case, unavoidable — are getting information through electronic means suggests that video displays should receive at least as prominent a place in schools as printed materials. Not an exclusive place, because print media will continue to play a highly important role, but the mix is changing. It's as if one continued to insist on teaching children to write

in the sand when clay tablets are available. We ought to mix some clay and sand.

We continue to pour enormous amounts of money into libraries that store periodicals and are heavy users of expensive paper stock. I don't know how many of you have had occasion to use Mead Data Central's Lexis law search service, which I think is marvelous, and recently it has been augmented by the Nexis periodical search service. I probably sound like an ad for Mead Data Central, but I own no stock with them, although they are among the hundred or so supporters of the program of which I am a part. My ability to use that resource has greatly altered the way I do research or, for that matter, the way I come to one of you when I want to raise money. I can go to a Nexis terminal and, in a few minutes, get a printout of what may have been said in the press about your organization within the last month or so. Then I come armed with your latest concerns at my fingertips instead of looking like an ignorant academic. The skill of search through a computer data base may be a more useful skill than learning about a conventional library.

Why will the newspaper survive in view of all the things you are talking about?

Oettinger: Because of one basic technological fact. If you've ever tried to play at retrieving information from a computerized system, you know that one of the things that computerized systems do terribly is browse. The sheer joy of taking a book or a newspaper, a conventional paper thing, flicking through the pages, and letting your eyes wander is something that no other medium that I know of today, or see in the offing, provides as well or as cheaply. And there are other relative advantages.

Now, that doesn't mean that the newspapers won't be in trouble. A major portion of their income comes from classified ads. The classified ad, however, is particularly vulnerable

— the display ad less so than the classified ad — to electronic depredations, partly because it's short and partly because it tends to be timely and can easily be dealt with electronically. The newspapers are, properly, seriously worried about the possibilities that the Yellow Pages or other forms of telephone directory may go electronic, worried that real estate consortia may make their own nationwide electronic house listing, which would siphon off ads. And once a major revenue-producing component of the industry has been destabilized, then other changes have to be created.

In my view, the change will not be a change to death, but transformation to some other shape. The precedent is the radio industry today. In the 1950s, when television finally took off, everybody predicted that the radio industry would die. It's alive and well and stronger than ever today, at least in name. What lies behind the name is something profoundly different from what it was in the 1940s. But the industry has survived; the stockholders have felt no pain; the management is fat and happy. But where radio once was the mass medium of choice, radio is today a specialized medium — fragmented, addressing particular audiences, but making money hand over fist doing that. I think the newspapers will experience discomfort — they can't help doing so — if some significant portion of their revenue base is eroded. They will be transformed in some way, but they will survive.

Tell us where satellites fit in.

Oettinger: Satellites are a nice example of excessive emphasis on a particular *technology* as opposed to a *function*. What satellites are good for is transmitting information. There are many other ways to transmit information, and the choice depends on the particular purpose — marketing this or that, talking to these or those people, transmitting this, that, or the other thing. The choice becomes a matter of what is

the cheapest, most efficient way for a particular buyer, or for the nation as a whole, to constitute its transmission scheme. For certain purposes, satellites are better than other means. For other purposes, they are terrible. The question of what kind of mix is appropriate either for a particular buyer or for the nation as a whole is a question far beyond what I can deal with briefly.

Can the satellite give us access to worldwide communication now?

Oettinger: Yes, but so can fiber optics or a pair of copper wires or any other among a number of means. The notion that the satellite is the only way to get around the world is hype. It usually originates from satellite folks.

Is it likely that the competition will be such that one side would try to get rid of the network and the other side would try to get rid of the newspaper?

Oettinger: It's not that simple. Certain phrases do us a great disservice. The "buggy whip" analogy is one because it is an exceptional case. Most industries don't die the way the buggy whip industry is said to have died. The product or service is transformed, but the corporate entity goes on.

Is there not an interaction between the kind of information technology that we can talk about, particularly with regard to newspapers and what has been happening in the last ten years to the WALL STREET JOURNAL and the NEW YORK TIMES, for example – the way they are published, distributed, and read around the country? Do you see a further continuation of that trend to the point that perhaps ten years from now the country might be served by basically a half-dozen newspapers?

Oettinger: That certainly is a trend. THE WALL STREET JOURNAL now prints itself

in a number of satellite plants not only around the country but also around the world. For some of the plants, the plates are made up in New York and transmitted, indeed by satellite, to the remote printing plant from which the paper is then distributed. This technology makes possible a simultaneous worldwide distribution that could not have been accomplished a decade ago. But in many instances, there is also some regional differentiation that enables regional marketing. I think that's an important element because, along with this national drift of the WALL STREET JOURNAL and of the others behind it, there is a countertrend which is the rapid growth of weeklies, suburban and rural papers, and so on.

While the major city dailies have been folding over the last couple of decades, the suburban papers have been growing. There are also some new art forms, like the shopper, which fill a void that, for my taste, might well be left unfilled. The shopper is the antithesis of the classified ad. It is the unclassified ad. To me, it makes no sense, but there is a clientele that likes to read jumbled advertising, likes going through columns and columns of disorganized stuff. They read it and buy what they read about. So that's a niche that has been carved, a very local or subregional niche, at a time when some of the national newspapers have retrenched or changed their stripes.

Keep in mind the significance of the fact that the definition of geography has changed. "Community" has changed. We used to be forced to interpret community as literally as a radius of *x* miles around some central point, the ancient village. Communities of interest now can be linked even if geographically dispersed. And so we see national chess-lovers magazines or national cheese-lovers magazines or what have you that are able to reach widespread audiences because the combined use of the U. S. mail, airplanes, and electronic means enable them to reach a diffuse audience economically. So we have a combination of nationalization in some

areas and fragmentation in others, and where it will end up is hard to predict.

Is the rate of technological change abating? Are we peaking, or is the rate going up — or "ain't we seen nothing yet?"

Oettinger: Oh, "we ain't seen nothing yet." I think that just the playing through of what's in the laboratory today is good for another couple of decades, and what will happen beyond is hard to forecast. We were amazed just a decade ago when new electronic circuits that would work in one-millionth of a second became available. We now have in the laboratory circuits that work at one-billionth-of-a-millionth of a second.

I came to Harvard as a freshman in 1947 because I wanted to study with Howard Aiken who, I read when I was in high school, had put together a computer. That computer once filled the entire first floor of the building that I'm in now. What was in that computer would now fit in the palm of my hand. It's comparable to a Hewlett-Packard that sells for about fifty bucks and fits in the palm of my hand. Machines that are now in common use in your enterprise, and might be the size of this room we're in will soon fit in a desk, consume less power, require less air conditioning, cost less and do more. Yes, there's still plenty to go, a profound transformation of everything.

Anthony G. Oettinger

Anthony G. Oettinger, Chairman of the Harvard Program on Information Resources Policy and of the Center for Information Policy Research, is Gordon McKay Professor of Applied Mathematics, Professor of Information Resources Policy, and a member of the Faculty of Government at Harvard University.

He is a member of the Command, Control, Communications and Intelligence panel of the Naval Research Advisory Committee and a member of the Scientific Advisory Group of the Defense Communications Agency.

He was chairman of the CATV Commission of the Commonwealth of Massachusetts (1975-79) and a member of that commission from its creation in 1972. He has served as a consultant to the National Security Council (1975-77) and to the Office of Science and Technology (1961-73). He has also been a member of the Research Advisory Board of the Committee for Economic Development (1975-79) and, since 1956, a consultant to Arthur D. Little, Inc.

From 1966 to 1968 he was president of the Association for Computing Machinery. He is a member of the Council on Foreign Relations and a Fellow of the American Academy of Arts and Sciences, the American Association for the Advancement of Science, and the Institute of Electrical and Electronic Engineers.